

# Cross Section Evaluation Working Group (CSEWG) Overview

David Brown  
National Nuclear Data Center

28 February 2022



@BrookhavenLab



# Before ENDF

**By 1960, there were many data efforts worldwide**

- different formats
- often hard-coded libraries
- proprietary data
- Notable efforts: UKNDL (AWE, UK), NDA library (US), ENDL (LRL, US)

**~1962 H. Honeck (BNL), A. Henry (Westinghouse), G. Joanou (GA) met at Colony Restaurant in DC decided on action**

- requested Reactor Mathematics and Computation Division of ANS to sponsor 2 meetings to link databases



<http://www.streetsofashington.com/2013/10/fine-dining-in-washington-dc-in-1950s.html>



# The Cross Section Evaluation Working Group produces ENDF/B library



**Formed 1966 & Chaired by BNL**

**Collaboration of many US programs,  
industry and international partners**

- If you see something in the library, at some point a sponsor somewhere wanted it

**All steps of nuclear data pipeline  
coordinated through CSEWG**

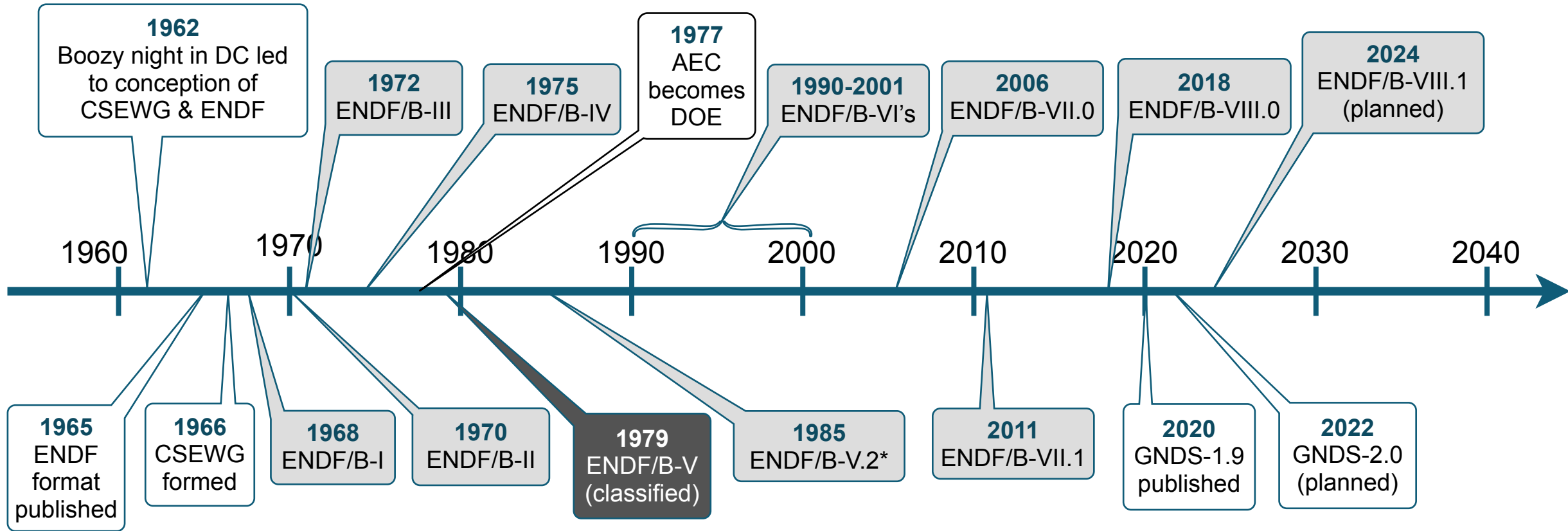
**Depending on what needs done, getting  
required data in library can be major effort**

**We are always open to new  
users and collaborators**



The December 2020 Nuclear Data Week at BNL was virtual. The picture was from the 2019 meeting and reminds us of better days.

# ENDF Timeline

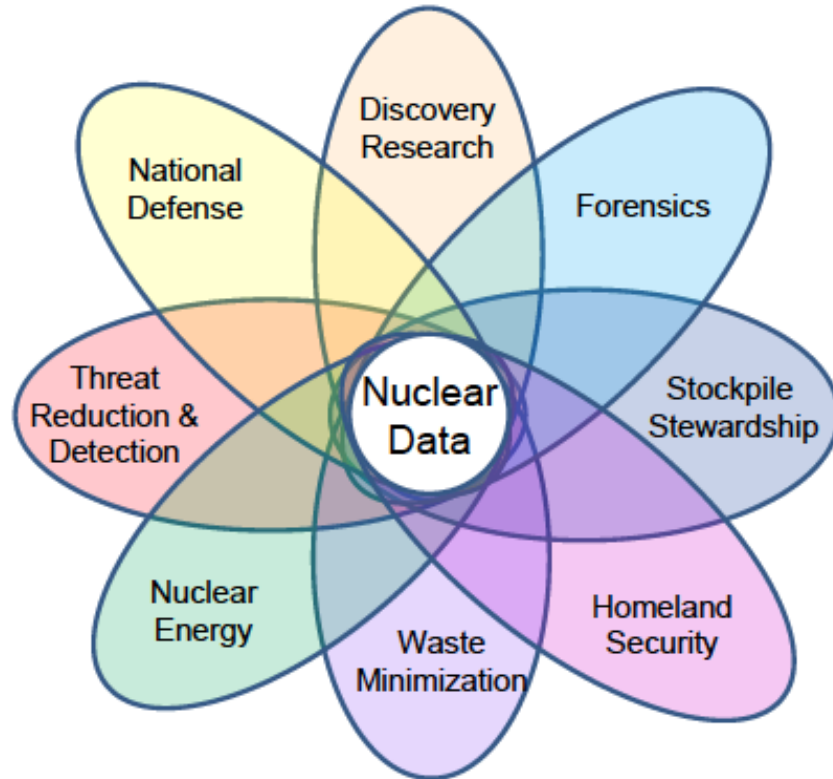


\* everybody's favorite release



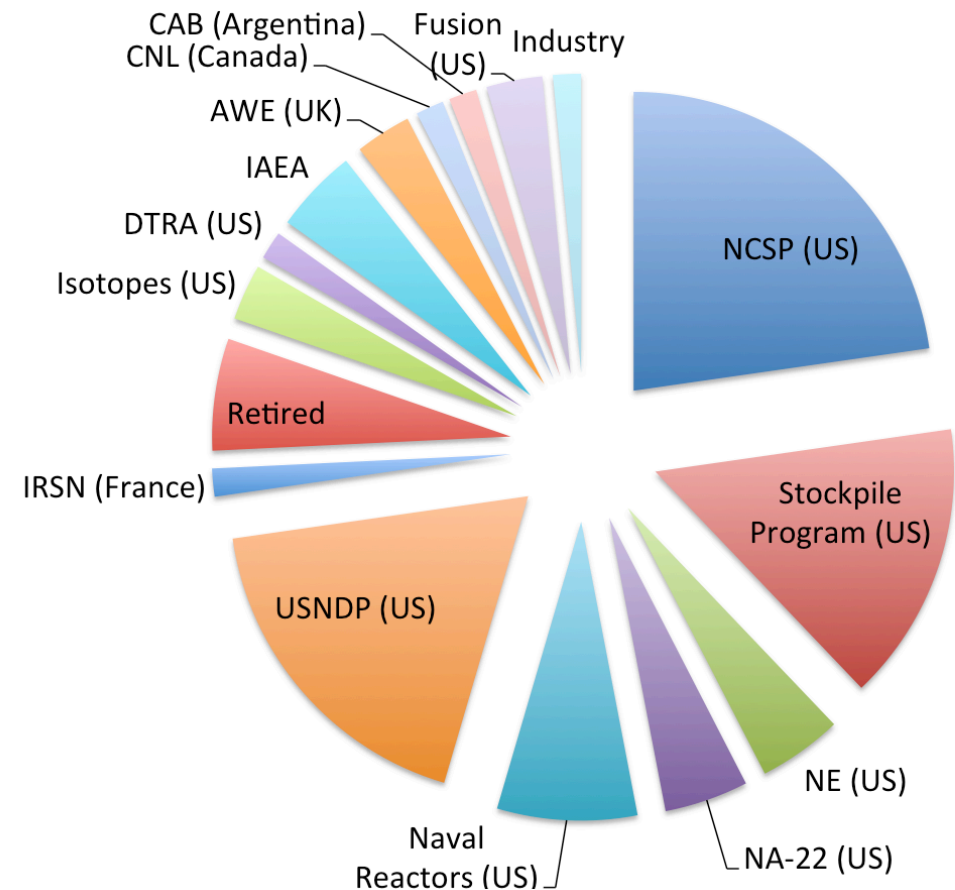
# CSEWG is a long standing collaboration between the data users who are also the biggest content providers

Intersections in Nuclear Data



Dr. Timothy Hallman, Associate Director of the Office of Science for Nuclear Physics  
April 5, 2015

Fraction of evaluations provided for  
ENDF/B-VIII.0



# By sharing through CSEWG many sponsors reap the benefit of collaboration

Program	Measurement	Theory	Compilation	Evaluation	QA (V&V, IE)	Infrastructure (gitlab, etc.)
DTRA	✓					
International (IAEA, NEA, ...)	✓	✓	✓	✓	✓	✓
NA-22	✓	✓		✓		
Naval Reactors	✓			✓	✓	
NCSP	✓	✓		✓	✓	✓
Nucl. En.					✓	
Other (NP, ICF, ...)	✓	✓				
Defense Prog.	✓	✓		✓	✓	✓
USNDP	✓	✓	✓	✓	✓	✓





Rensselaer



NIST

NC STATE  
UNIVERSITY



# CSEWG is not limited to the Americas





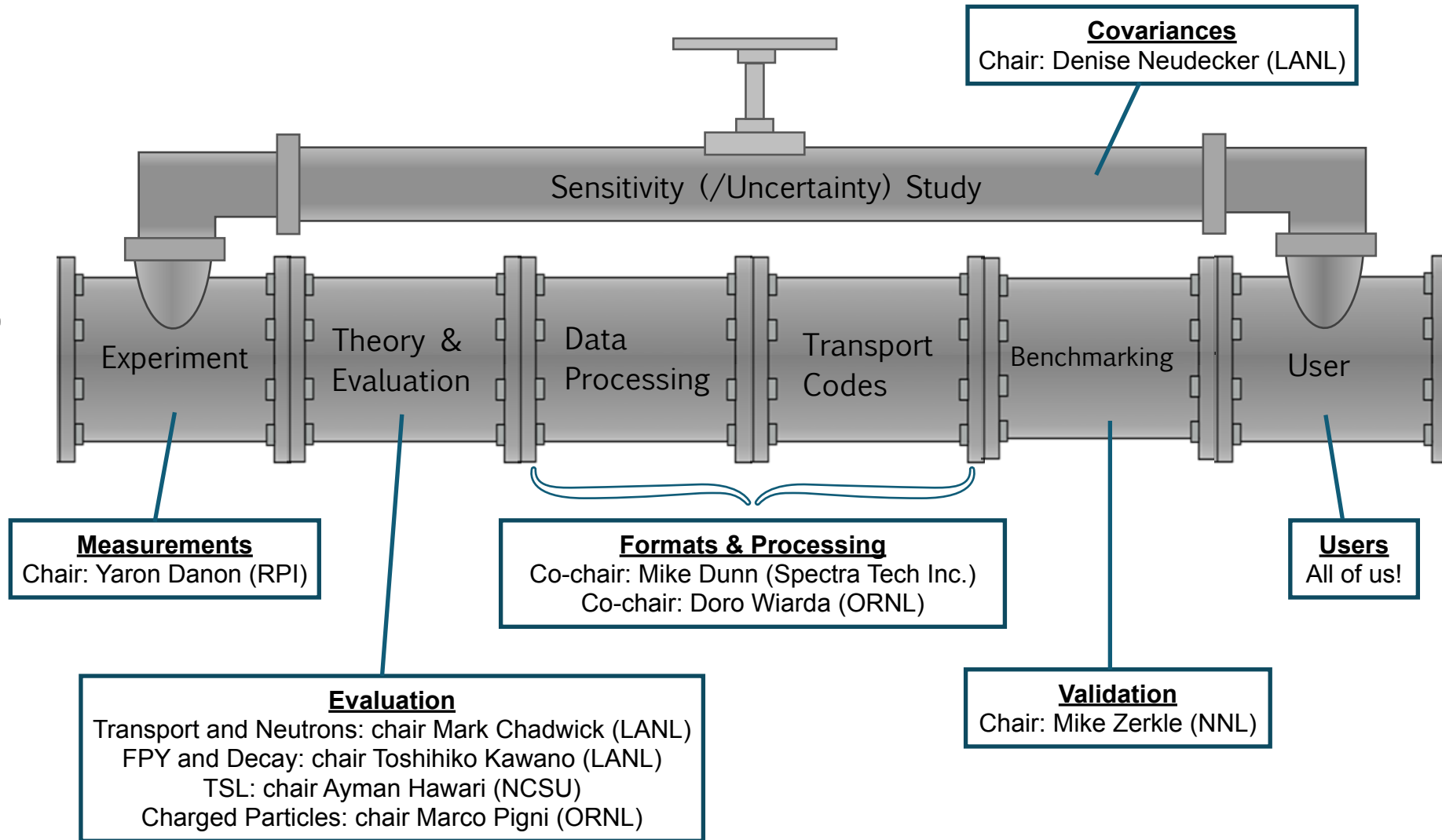
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## Chair:

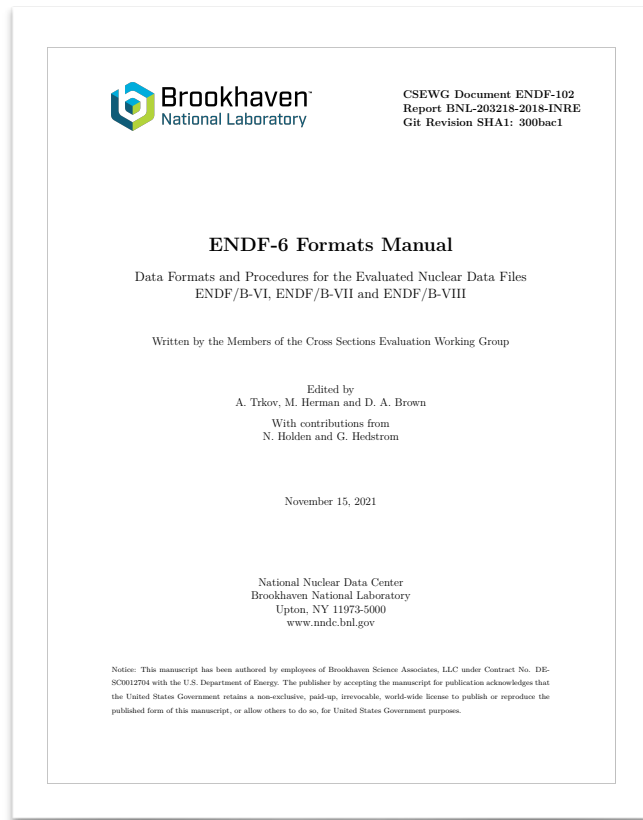
David Brown (BNL)  
[dbrown@bnl.gov](mailto:dbrown@bnl.gov)

## Library Manager:

Gustavo Nobre (BNL)  
[gnobre@bnl.gov](mailto:gnobre@bnl.gov)



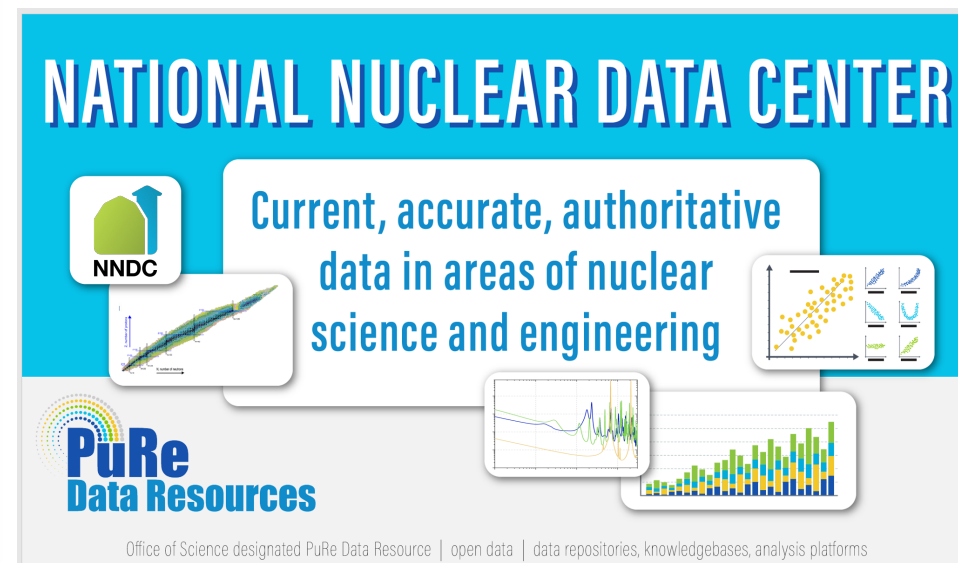
## ENDF Formats



## ENDF Releases



## ENDF Files





## ENDF Formats



CSEWG Document ENDF-102  
Report BNL-203218-2018-INRE  
Git Revision SHA1: 300bac1

### ENDF-6 Formats Manual

Data Formats and Procedures for the Evaluated Nuclear Data Files  
ENDF/B-VI, ENDF/B-VII and ENDF/B-VIII

Written by the Members of the Cross Sections Evaluation Working Group

Edited by  
A. Trkov, M. Herman and D. A. Brown  
With contributions from  
N. Holden and G. Hedstrom

November 15, 2021

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Upton, NY 11973-5000  
www.nndc.bnl.gov

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## ENDF Releases



Volume 148, February 2018

ISSN 0090-3752

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Special Issue Assistant Editor: Boris Pritychenko

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## ENDF Files

## NATIONAL NUCLEAR DATA CENTER



Current, accurate, authoritative  
data in areas of nuclear  
science and engineering



Office of Science designated PuRe Data Resource | open data | data repositories, knowledgebases, analysis platforms

# ENDF format & ontology was (and still is) tied to original infrastructure

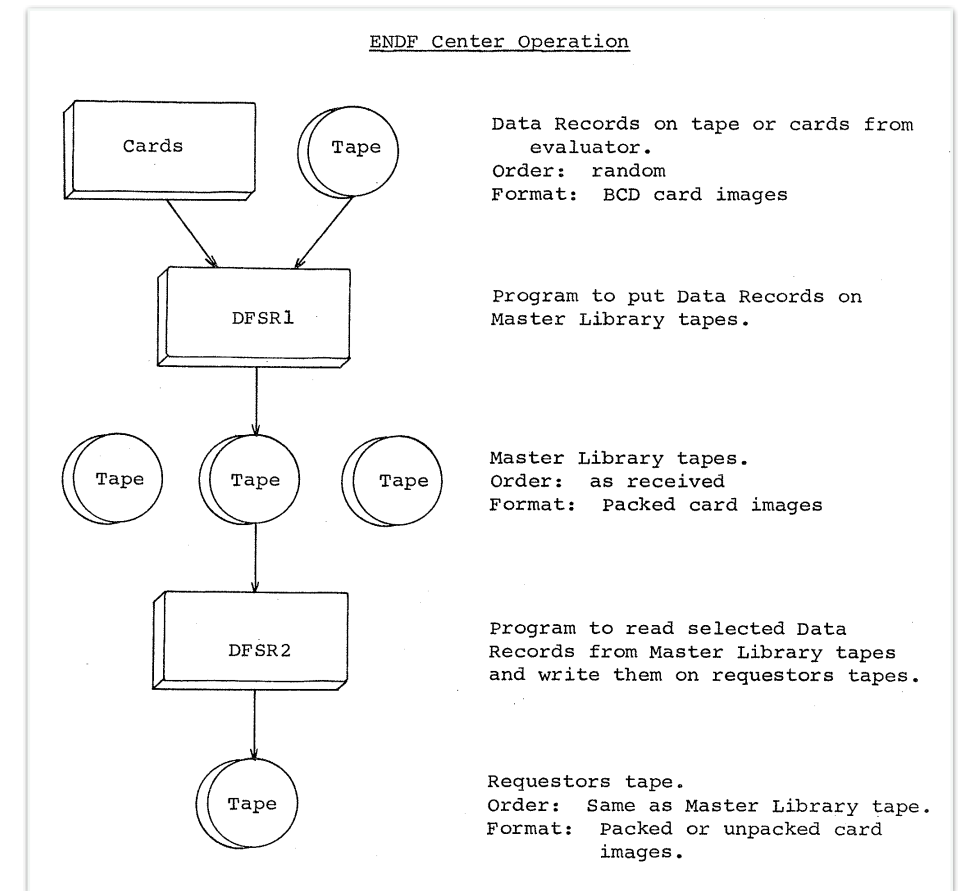
Original format designed to fit on IBM  
80 column punchcards

- Evaluations actually were occasionally submitted on punchcards

Original data stored on magnetic tapes

It was possible to request ENDF data on  
tapes and/or punchcards

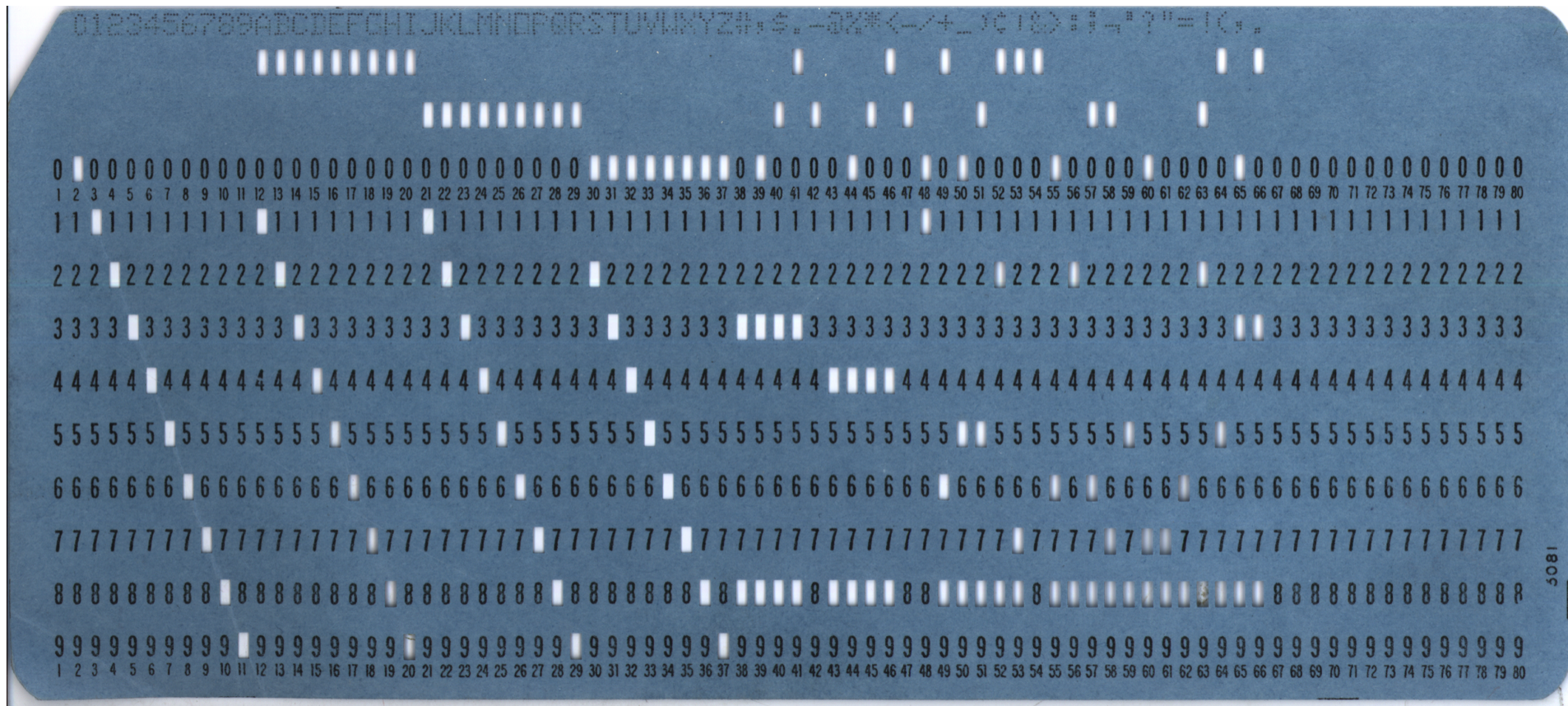
- Punchcard format was discouraged, BNL was trying to phase them out



From BNL-8381 (1966)



# This is an IBM 80 column punchcard



[https://en.wikipedia.org/wiki/Punched\\_card#/media/File:Blue-punch-card-front-horiz.png](https://en.wikipedia.org/wiki/Punched_card#/media/File:Blue-punch-card-front-horiz.png)

# This is a chunk of the n+59Co evaluation: it's punchcard-ready

		14		83		1		02725	1451	286
		14		84		1		02725	1451	287
		14		85		1		02725	1451	288
		14		86		1		02725	1451	289
		14		87		1		02725	1451	290
		14		88		1		02725	1451	291
								2725	1	099999
								2725	0	0
2.705900+4	5.842690+1	0		0		1		02725	2151	1
2.705900+4	1.000000+0	0		0		1		02725	2151	
1.000000-5	1.000000+5	1		3		0		12725	2151	3
3.500000+0	6.672000-1	0		0		2		32725	2151	4
5.842690+1	6.672000-1	0		0		600		1002725		
-5.000000+3	3.000000+0	5.576800+2	9.215100+0	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
-5.000000+3	4.000000+0	1.898100+2	1.868200-1	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
-4.767000+2	4.000000+0	1.949000-2	2.148900+0	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
-2.258800+2	3.000000+0	9.164400+0	5.214100-2	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
1.320000+2	4.000000+0	5.270100+0	4.700000-1	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
4.323100+3	4.000000+0	1.041400+2	4.173700-1	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
5.016000+3	3.000000+0	6.789601+2	1.332200+0	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		
6.389700+3	4.000000+0	1.681100+0	3.155600-1	0.000000+0	0.000000+0	0.000000+0	0.000000+0	02725		

Line number, so you can put your punchcards back in order if you drop them



# ENDF & GNDS Formats

- **New NCSP relevant formats**

- Mixed elastic scattering TSL data for nuclides with both coherent and incoherent components (M. Zerkle NNL)
- Background R-matrix format (J. Brown ORNL)

- **GNDS & ENDF have similar format approval process**

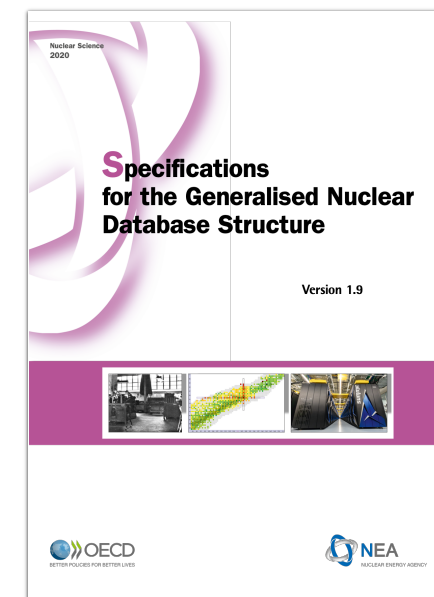
- Harness power of gitlab
- Contact D. Brown (EG-GNDS chair) or D. Wiarda (ENDF Formats chair) for information

- **GNDS-1.9 published**

- Specifications: <https://oecd-nea.org/download/wpec/documents/7519-GNDS.pdf>
- XML Schema for GNDS-1.9: <https://www.oecd-nea.org/download/wpec/gnds/gnds.xsd>
- GNDS Webinar: <https://www.youtube.com/watch?v=h9Byrkxr8LE&feature=youtu.be>

- **GNDS-2.0 approved by Expert Group, will submit to full WPEC in May**

The screenshot shows a video player interface. At the top, the title is "Nuclear data are the 'secret sauce' that grab our understanding of nuclear systems". Below the title, there's a subtitle "The Generalised Nuclear Database Structure". The video content includes a 3D visualization of a nuclear reactor core and a bar chart showing the growth of nuclear data over time. Text overlays on the video state: "Nuclear reactions are too complex to model from first principals and must be tabulated for use in simulations" and "The size and complexity of reaction data has increased markedly in the last 20 years". A play button is visible over the video. In the bottom right corner, there's a caption: "VERA simulation of Xe-125 production in WB2 reactor core, from 'Predictive Power' https://www.ornl.gov/news/predictive-power (2017)".





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# ENDF/B-VIII.0 was released on 2 Feb. 2018 by the Cross Section Evaluation Working Group (CSEWG)



## Integrates contributions for many sources

- **Neutron Standards** *IAEA, NIST*
- **CIELO Pilot Project** *BNL led Fe, LANL led  $^{16}\text{O}$  and  $^{239}\text{Pu}$ , IAEA led  $^{235,238}\text{U}$*
- **Many new and improved neutron evaluations** *(DP, Crit. Safety, NE, USNDP)*
- **New thermal scattering libraries** *(Crit. Safety, Naval Reactors)*
- **Charged particles** *USNDP (LLNL)*
- **New atomic data** *(LLNL)*
- **Success rests on EXFOR library** *IAEA project but USNDP (BNL) coordinates compilation of reaction data for Western Hemisphere*

Happy  
50<sup>th</sup>  
Anniversary!

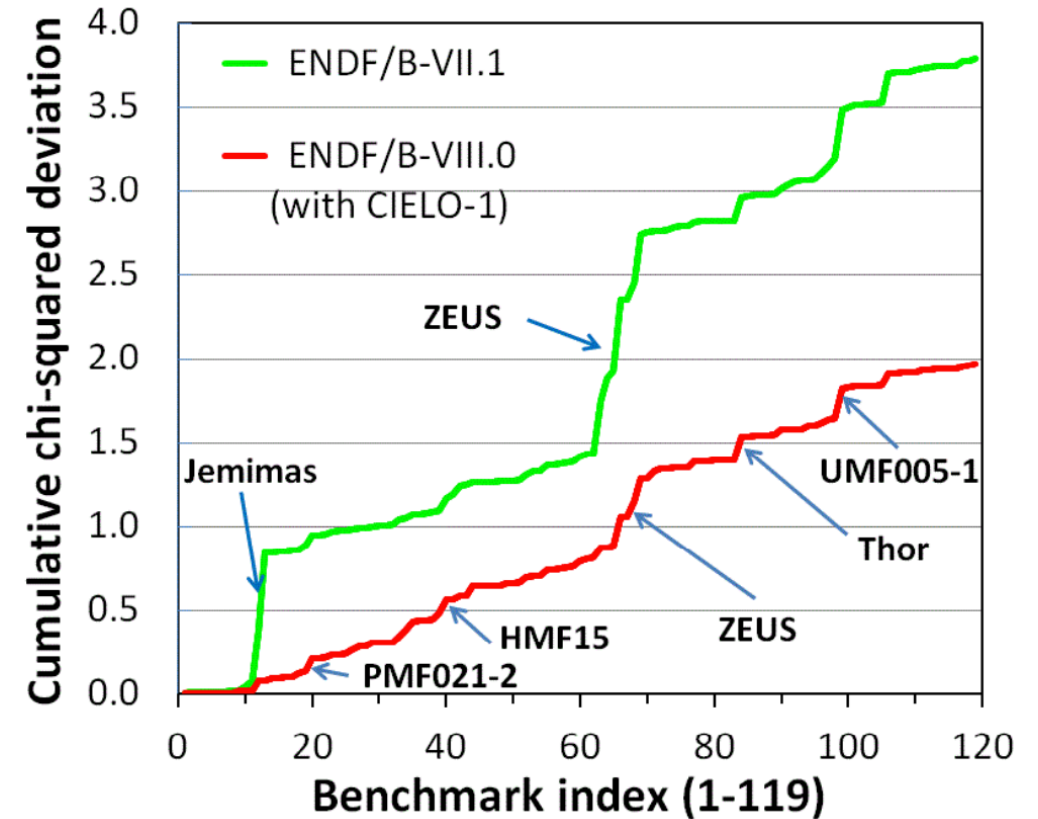
# ENDF/B-VIII.0 is our best performing and highest quality library yet

Validate by simulating well characterized systems

- 1198 critical assembly benchmarks
- 14 MeV source transmission
- Many other tests

Quality also assured by

- ADVANCE continuous integration system at BNL
- Annual Hackathons



M.B. Chadwick et al, Nuclear Data Sheets 148, 189 (2018)



# Library and evaluations detailed in Nuclear Data Sheets vol. 148 (2018)

- ENDF/B-VIII.0:** D. Brown *et al.*,  
Nuclear Data Sheets 418, 1 (2018)
- Neutron Data Standards:** A. Carlson *et al.*,  
Nuclear Data Sheets 418, 143 (2018)
- CIELO Overview:** M.B. Chadwick, *et al.*,  
Nuclear Data Sheets 148, 189 (2018)
- CIELO Iron:** M. Herman, *et al.*,  
Nuclear Data Sheets 148, 214 (2018)
- CIELO Uranium:** R. Capote, *et al.*,  
Nuclear Data Sheets 148, 254 (2018)
- PFNS evaluation:** D. Neudecker, *et al.*,  
Nuclear Data Sheets 148, 293 (2018)
- $^{239}\text{Pu}(n,g)$  measurement:** S. Mosby, *et al.*,  
Nuclear Data Sheets 148, 312 (2018)
- $^{235}\text{U}$  PFNS measurement:** M. Devlin, *et al.*,  
Nuclear Data Sheets 148, 322 (2018)



# Next ENDF/B Release

# ENDF/B VIII.1

Last ENDF/B release (VIII.0): Feb. 2018

“Minor” release (VIII.1) targeted for Feb. 2023

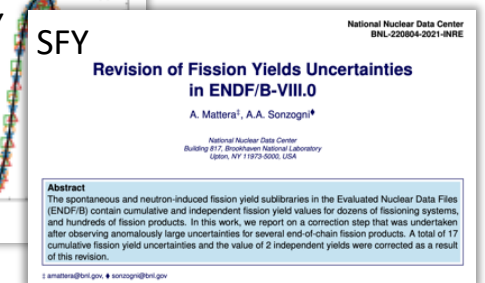
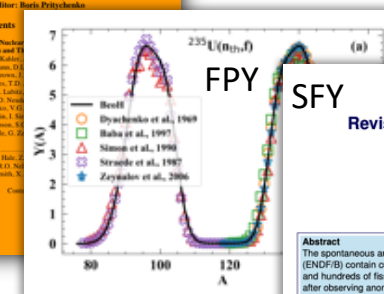
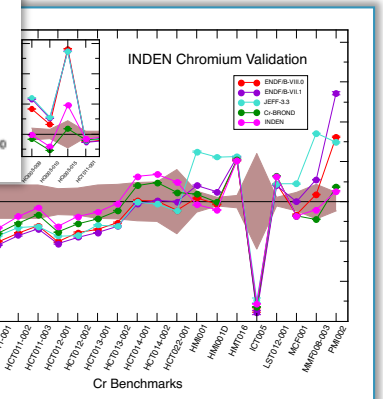
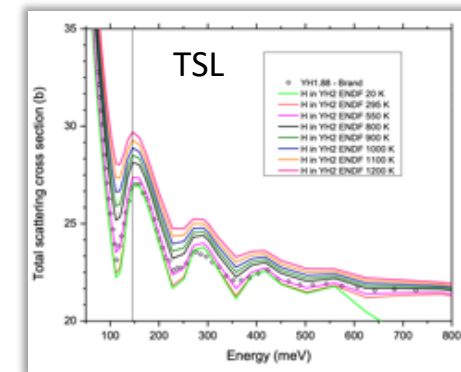
- Only ENDF major releases contain new Standards evaluations.
- INDEN ( $^{56}\text{Fe}$ ,  $^{50,52,53,54}\text{Cr}$ ,  $^{28-30}\text{Si}$ ,  $^{16,18}\text{O}$ ,  $^{233,235}\text{U}$ ,  $^{239}\text{Pu}$ , ...)
- TSL (FLiBe, paraffinic oil, HF,  $\text{ZrH}_x$ , ...)
- FPY
- More is coming!

New evaluations directly impact new reactor concepts (e.g. SMR, MSR, ...)

New BNL Leadership

- New CSEWG Chair & ENDF Library Manager

“Big paper” to be published in NDS



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Office of Science designated PuRe Data Resource | open data | data repositories, knowledgebases, analysis platforms



# Where to get the files

- In development files available at [git.nndc.bnl.gov](https://git.nndc.bnl.gov), contact G. Nobre ([gnobre@bnl.gov](mailto:gnobre@bnl.gov)) for access; note access is limited due to cost so please provide a justification
- All ENDF releases except ENDF/B-I available at [www.nndc.bnl.gov](http://www.nndc.bnl.gov), but locations may change...
  - We are assigning DOI's to libraries and generating proper landing pages
  - About ENDF/B-I, it is lost. If you have seen a copy, please email me

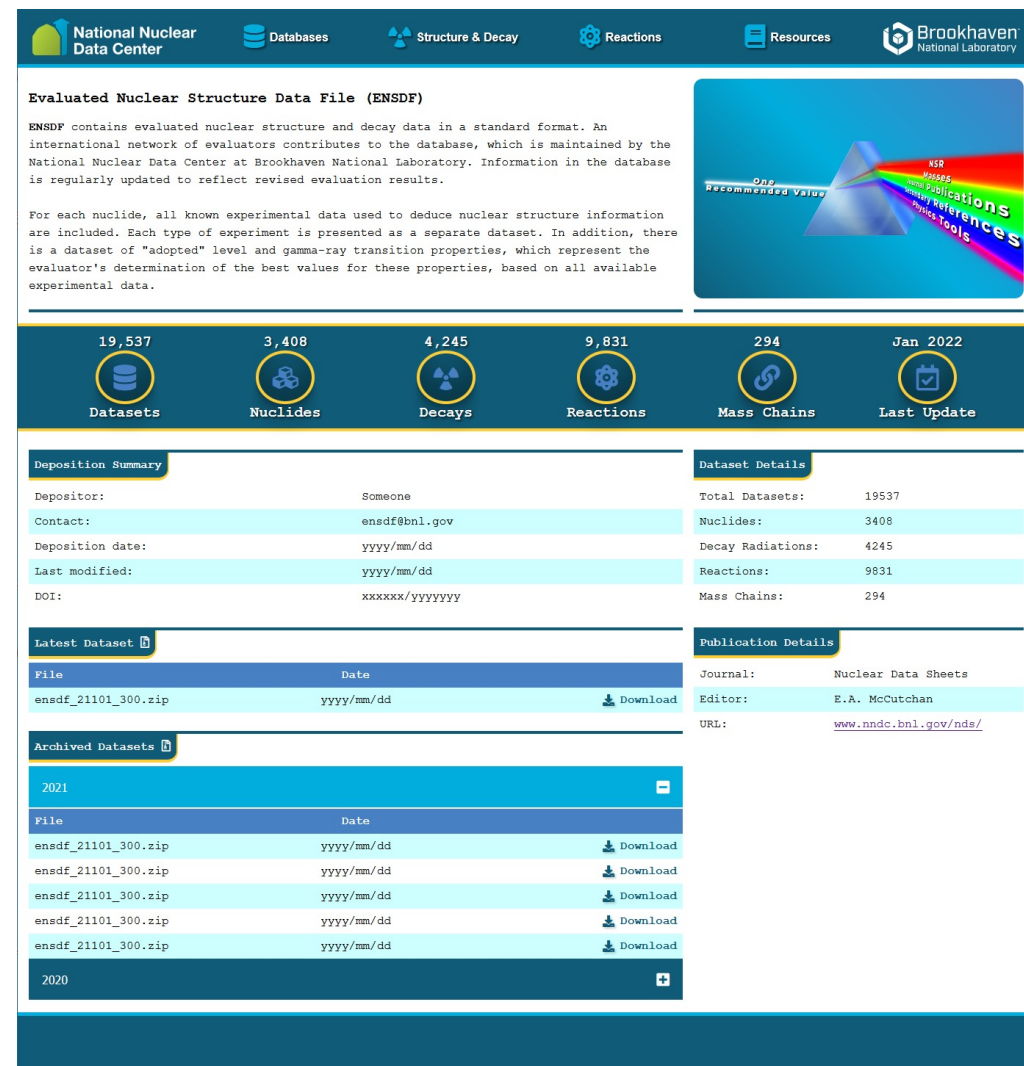
# PuRe implementation status

## Robust cloud backup since Sep. 2021

- One of a kind at BNL
- Backs up 15 TB of data from on-premise, mission-critical servers to AWS GovCloud
- Continuous replication
- During a disaster:
  1. Server backup restored from AWS GovCloud to create production-ready instance.
  2. Accessible within hours.
- Annual cost: \$12k - \$15k

## Merging NNDC library with OSTI & BNL libraries

- C. Dunn cataloging & digitizing NNDC library
- OSTI gets digital copies, BNL gets paper



**National Nuclear Data Center** | Databases | Structure & Decay | Reactions | Resources | Brookhaven National Laboratory

### Evaluated Nuclear Structure Data File (ENSDF)

ENSDF contains evaluated nuclear structure and decay data in a standard format. An international network of evaluators contributes to the database, which is maintained by the National Nuclear Data Center at Brookhaven National Laboratory. Information in the database is regularly updated to reflect revised evaluation results.

For each nuclide, all known experimental data used to deduce nuclear structure information are included. Each type of experiment is presented as a separate dataset. In addition, there is a dataset of "adopted" level and gamma-ray transition properties, which represent the evaluator's determination of the best values for these properties, based on all available experimental data.

One Recommended Value | Experimental Data | Publications | References

19,537	3,408	4,245	9,831	294	Jan 2022
Datasets	Nuclides	Decays	Reactions	Mass Chains	Last Update

#### Deposition Summary

Depositor:	Someone
Contact:	ensdf@bnl.gov
Deposition date:	yyyy/mm/dd
Last modified:	yyyy/mm/dd
DOI:	xxxxxx/yyyyyyy

#### Latest Dataset

File	Date	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download

#### Archived Datasets

File	Date	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download
ensdf_21101_300.zip	yyyy/mm/dd	Download

#### Dataset Details

Total Datasets:	19537
Nuclides:	3408
Decay Radiations:	4245
Reactions:	9831
Mass Chains:	294

#### Publication Details

Journal:	Nuclear Data Sheets
Editor:	E.A. McCutchan
URL:	<a href="http://www.nndc.bnl.gov/nds/">www.nndc.bnl.gov/nds/</a>

**Our first DOI landing page – for the full ENSDF library!**  
**ENSDF has a newly minted DOI, NSR & XUNDL are next!**

# Final comments

- CSEWG is “here to help”
- Welcomes collaboration in and out of US (but inside is easier)
- Data is (when complete) OPEN
- Long tradition of quality/continuous improvement
- Conservative, driven by experiment when possible
- Golden Rule (whoever has the gold makes the rules)